Potential Markets for Partially Acetylated Cotton

AMS-324

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Marketing Service • • • Marketing Research Division

PREFACE

This report presents the results of a joint research effort by the Marketing Research Division of the Agricultural Marketing Service and the Southern Utilization Research and Development Division of the Agricultural Research Service. The study is one of a number of projects in a growing area of cooperative research combining the talents of economists and physical scientists to provide answers on the commercial feasibility and market potentials of new or improved products developed through utilization research.

The report was prepared under the general supervision of M. E. Miller, Market Development Branch, Marketing Research Division; and E. L. Patton and F. S. Perkensen, Southern Utilization Research and Development Division. The study is part of a broad program of continuing research designed to expand markets for farm products.

CONTENTS

July 1959

POTENTIAL MARKETS FOR PARTIALLY ACETYLATED COTTON

By Frank D. Barlow, Jr., Market Development Branch, Agricultural Marketing Service; Albert S. Cooper, Jr., and Henry L. E. Vix, Southern Utilization Research and Development Division, Agricultural Research Service

SUMMARY

For a number of years the Southern Utilization Research and Development Division of the Agricultural Research Service has conducted research on the chemical modification of cotton fabrics, yarns, and fibers as a means of achieving new chemical, physical, and textile properties. Partially acetylated cotton was among the first chemically modified cottons investigated. Because of certain of its improved properties and the cost at which these may be obtained, partially acetylated (PA) cotton appears to have a good chance of being fully commercialized.

Improved properties resulting from partial acetylation are resistance to rot, mildew, heat, and scorch. Since cotton can be made resistant to rot and mildew by other chemical treatments at less cost than by partial acetylation, the opportunity for commercializing PA cotton is confined primarily to utilizing the improved properties of heat and scorch resistance. These characteristics are of greatest importance in commercial laundry industry uses and for home ironing-board covers.

All available information on service evaluation tests in commercial laundries was reviewed as a basis for determining the suitability of PA cotton in these uses. Service evaluation tests in which fabrics were exposed to sustained temperatures of 300°F. or more indicate that the service life of PA cotton approximates 4 times that of untreated cotton.

Estimated costs based on pilot plant and commercial operations provided a basis for assuming a favorable competitive position for PA cotton versus untreated cotton and other materials in commercial laundries.

Assuming a favorable competitive position, the possible market penetration was projected at several assumed levels using published statistics on cotton consumption in the laundry industry in 1956 and estimates of the share of this market held by cotton as compiled by the National Cotton Council. A 50 percent penetration of the market now held by competing materials and untreated cotton would give PA cotton a market equivalent of approximately 17,000 bales of cotton. If the penetration was 100 percent of the market for other competing materials and 50 percent of that for untreated cotton, the market equivalent would be approximately 27,500 bales of cotton.

The service life of PA cotton in laundry uses is about 4 times that of untreated cotton. Thus the market equivalent for PA cotton is about one-fourth the quantity of cotton that would be used if untreated cotton maintained its present share of the market and recaptured markets lost to competing materials. However, present market trends indicate that competing materials might make further inroads into the part of the market still retained by untreated cotton. Therefore retention of any portion of the market now held by untreated cotton and any improvement in cotton's competitive position in the portion of the market now held by other products could be considered long-term gains in cotton consumption.

The market potential for PA cotton for use as home ironing-board covers is estimated to be 2,225 bales. This estimate is based on existing price-cost relationships and on the possibility of capturing the market now held largely by asbestos materials in higher priced ironing-board covers. Effective promotion on the basis of longer service life and better general appearance of PA covers than other covers, and reduction in price of PA covers as production increases, could result in broadening the area of the market for home ironing-board covers in which PA cotton would be competive.

INTRODUCTION

The modern concept of production and marketing is to utilize advancing technical knowledge to produce new or improved products from a widening choice of raw materials, and to market products developed for special applications. This specialization of products applies generally throughout our economy, particularly in the textile industry where fibers with specialized qualities are being developed and promoted for specific applications. It is generally recognized, therefore, that fabrics having qualities suitable for specific uses are essential as our economy gears itself to modern production technology.

For a number of years the Southern Utilization Research and Development Division (SURDD) of the Agricultural Research Service has conducted research on means of imparting specialized qualities to cotton fibers, yarns, and fabrics by chemically changing the cotton cellulose. Chemical modification of cotton can result in products having physical and chemical properties greatly different from ordinary or untreated cotton. In fact, chemically modified cottons should be considered new fibers, in some cases similar to the new synthetic fibers that have new or improved functional qualities for textile products. The ultimate objective of research on the chemical modification of cotton is to combine desirable functional qualities in such new proportions as to improve cotton's competitive position. Untreated cotton is losing some market outlets to new fibers or other competing materials that have been processed specifically to meet the critical requirements of particular end uses.

One of the chemical modification processes for cotton that have been extensively investigated at the Southern Utilization Research and Development Division is that of partial acetylation. This process involves the conversion of the more readily accessible cellulose hydroxyl groups to cellulose acetate.

The product is partially acetylated cotton, referred to as "PA cotton" in this report. The earliest recognized investigation of this product and process occurred in England about 50 years ago. The process was investigated then as a means of improving the resistance of cotton to the destructive action of sea water. Even though the PA cotton products were excellent in their resistance to the microbiological activity of sea water, large-scale commercial production has not resulted. At present there are two companies producing PA cotton fabrics commercially: One is in the United States and the other is in England.

The initial interest of the U. S. Department of Agriculture in PA cotton came as a result of the wartime need for a permanent rot-proofing treatment by the military forces. In recent years, other physical and chemical properties of PA cotton have been investigated that show promise for special uses (2). 1/

NEW PROPERTIES AND CHARACTERISTICS OF PA (PARTIALLY ACETYLATED) COTTON

PA cotton possesses several properties and characteristics that ordinary cotton does not have. The most important of these for practical applications are:

1. Heat resistance.--Withstands sustained temperatures up to 320° F. with an increased practical service life approximately 4 times that of untreated cotton. According to Moncrieff PA cotton withstands high temperatures up to 10 times as long as untreated cotton (8).

2. Scorch resistance.--Withstands 30 minutes of direct contact with an electric iron at 400° F. without discoloration. 2/

3. Mildew resistance.--According to pure culture tests PA cotton is completely resistant to attack of mildew (1, 11).

4. Rot resistance.--In soil burial tests PA cotton of suitable acetyl content retained 90 percent of its original breaking strength after 50 weeks as compared to untreated cotton which was completely destroyed after one week's burial (5).

For the purpose of this analysis of the market potential of PA cotton, the above properties were combined into only two classifications. This was done because most applications requiring heat resistance would also require scorch resistance, and those requiring rot resistance would usually require mildew resistance as well.

These improved properties are probably the outstanding functional qualities of PA cotton for practical application. Other properties altered

---

1/ Underscored numbers in parentheses refer to items in Literature Cited, p. 22.

2/ Unpublished data, SURDD tests.

by acetylation that may be considered as improved functional qualities for some applications are:

1. Acid resistance.--Approximately twice that of untreated cotton (6).

2. Reduced moisture absorbency.--Approximately one-half that of ordinary cotton (10).

3. Reduced swelling tendency when wet.--Approximately one-half that of untreated cotton.

4. Changed dyeing characteristics.--Dyes with direct acetate dyes.

5. Increased resistance to electrical breakdown.--Better electrical insulating characteristics.

6. Thermoplasticity.--Exhibits thermoplastic characteristics at acetyl contents above 25 percent (3).

Partial acetylation achieves new characteristics that may be of importance in specific uses. However, laboratory tests indicate that the process adversely affects or does not improve certain desirable functional qualities possessed by untreated cotton such as: 3/

1. Tenacity.--Properly acetylated fibers, yarns or fabrics have approximately the same breaking strength before and after treatment. However, if the weight of the treated product is considered, tenacity is reduced by a percentage approximately equal to the percentage of added weight resulting from acetylation.

2. Flex abrasion.--Reduced 50 to 85 percent depending on the construction of the material being treated.

3. Tear strength.--Tear strength is reduced 40 to 60 percent depending on the construction of the material being treated.

4. Flat abrasion.--Resistance is approximately equal to that of the unacetylated control cotton fabric.

5. Elongation.--Elongation is usually reduced from 10 to 15 percent.

Fortunately, partial acetylation does not reduce these properties enough to greatly hinder the use of PA cotton in particular products where an improved property is a major consideration. It has long been recognized that ordinary or untreated cotton possesses some physical properties that are far in excess of the marginal requirements for use in many textile applications. Figure 1 shows that if cotton is used in a product that is subjected to service conditions equivalent to heating for 1 day at 160° C., the PA cotton should last at least 7 times as long if flex life is taken as an indication of service life. Figure 2 shows that a similar relationship

3/ Unpublished data, SURDD tests.

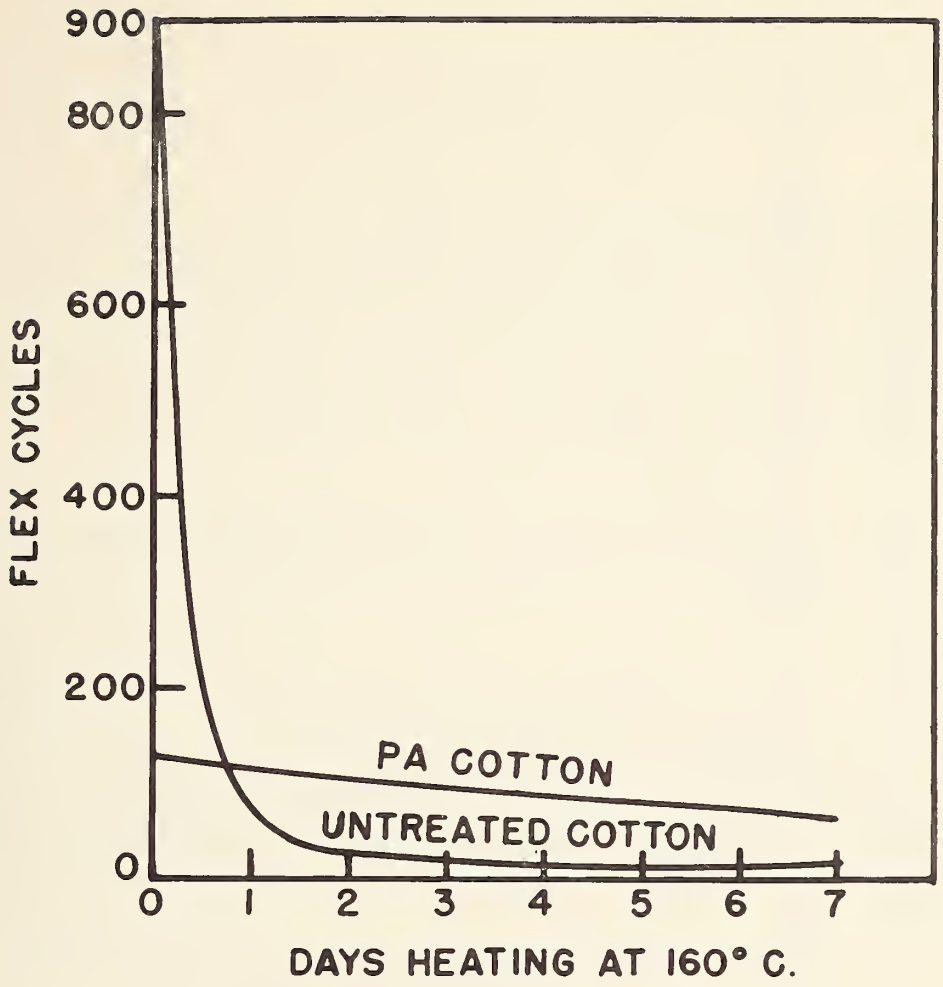

Figure 1.--The effect of heating on the flex endurance of PA and untreated cotton fabric.

exists for tearing resistance. Other physical measurements give similar results. Retention of a given physical property for an extended time during service is the primary consideration in selecting a material for a particular application. This particular chemical modification results in a product with some important new and improved use qualities as well as one with some reduced functional properties. However, the added net service life as related to cost is the factor which largely determines the value of an industrial product, and the present market analysis is made on that basis.

POTENTIAL MARKETS

If all of the many different cotton markets are analyzed and those requiring qualities that are imparted or improved by acetylation are selected, a possible annual PA cotton market of several hundred thousand bales can be envisioned.

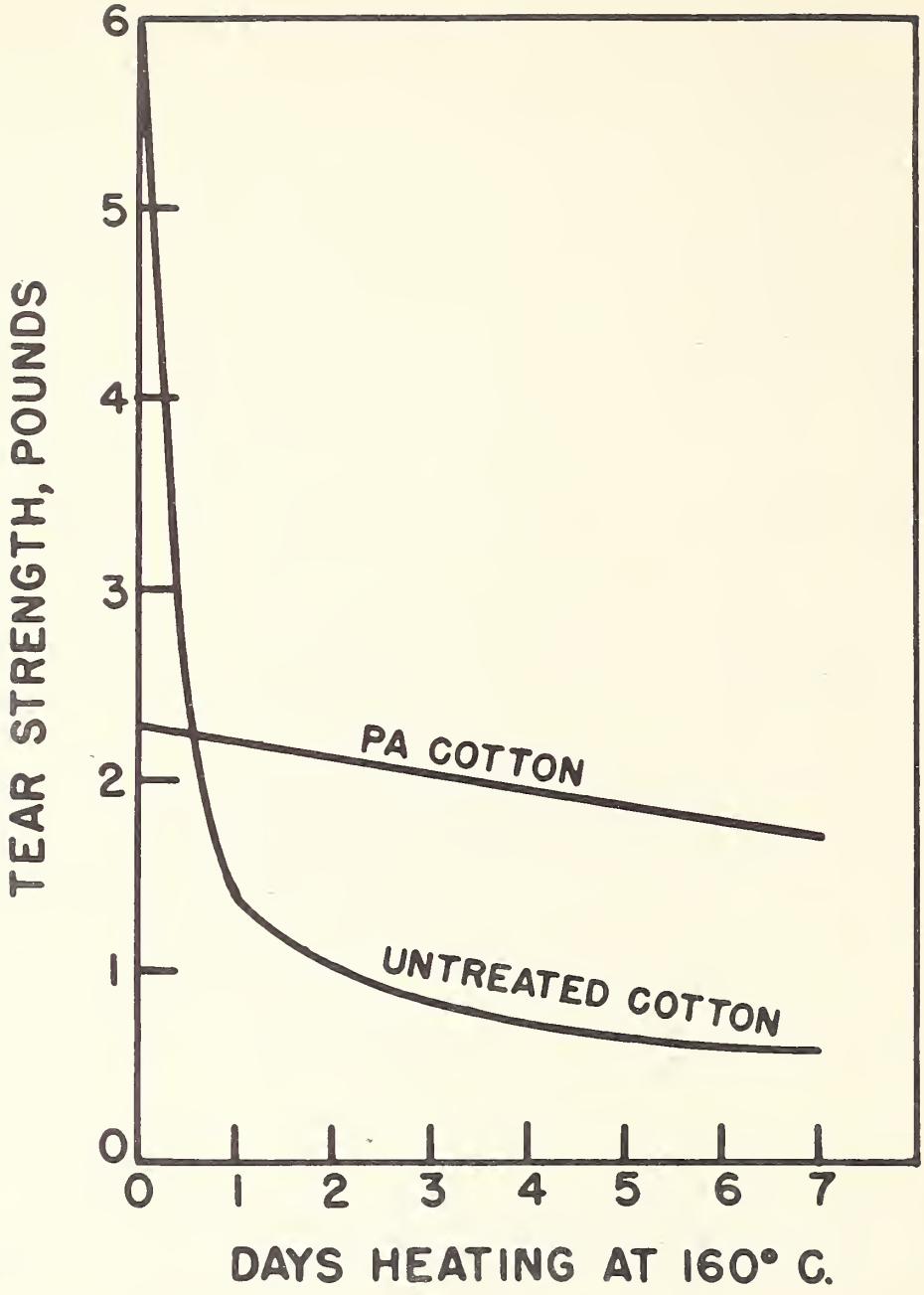

Figure 2.--The effect of heating on the tear strength of PA and untreated cotton fabric.

A more practical examination of each of these markets, however, shows that many must be eliminated because of treatment costs alone or because of lack of other qualities in PA cotton. Only those products requiring resistance to heat, scorch, mildew, or rot as a primary quality are considered as practical potential markets for PA cotton at this time.

In this analysis it appeared that a preliminary estimate of the immediate practical market potential was of more value than an estimate of the ultimate market potential of PA cotton. On the basis of known facts the immediate practical market potential for PA cotton is limited essentially to products in which heat and scorch resistance are primary requirements for achieving greater serviceability. In particular, it is believed that the largest potential market for PA cotton in its present stage of development is limited to laundry covering and to press foundation material in household and commercial laundries.

Resistance to mildew, which is important in humid climates in awnings, other canvas products, automobile tops, and many other items, can be obtained at lower costs by treating the fabric with certain mildew inhibitors. 4/ Consequently, it is not likely that PA cotton would be used because of its resistance to mildew alone.

Although PA cotton shows outstanding resistance to attack by microorganisms in soil burial tests, there is no known large-volume use other than sandbags, tents, and certain military items in which rot resistance might be considered an important requirement. It does not now appear that any significant volume of PA cotton would be used in sandbags, as the cost of the PA cotton fabric would be at least 50 percent above untreated cotton which is currently more dear than competing materials such as jute and treated paper. Use of PA cotton in tents is also problematical because of the increased cost and the interrelationships of rot resistance to other functional qualities also desirable in tents. 5/

4/ Estimated cost of treating cotton fabric with 1 percent copper 8-quinolinolate, 0.18 percent copper, and 6 percent urea formaldehyde to obtain mildew and rot resistance is approximately 2 cents per yard for 6-ounce duck. The estimated cost for the partial acetylation of 8-ounce, 60" sheeting ranges from 9.6 cents per yard by the continuous process with 90 percent chemical recovery at an annual production of 12 million yards to 36.9 cents per yard using the batch process with essentially no chemical recovery at an annual production of one-fourth of a million yards.

5/ The Department of Defense for a number of years has shown much interest in chemical treatments to impart mildew and rot resistance to fabrics for military uses, but for various reasons have not indicated any interest in purchasing PA cotton fabrics. In the absence of interest on the part of the Defense Department it does not appear that there is much possibility of any great demand for PA cotton because of its mildew and rot resistance. Frequent mention has been made of the potential use of PA cotton for irrigation equipment and ditch bank covers, but little enthusiasm has been shown by those experimenting with its use. Competition is keen in this field where cost of the material in relation to service is the major consideration. Exploration

The functional importance of the greatly improved properties possessed by PA cotton is limited almost exclusively to the industrial market. Of the industrial market, laundry applications appear to offer the most favorable opportunity for utilizing the improved properties of PA cotton and for utilizing the material in significant quantities. These properties are not of overriding importance in clothing or in household items with the possible exception of home ironing-board covers. 6/

There are indications that other industrial products or even some clothing may utilize one or more of these new or improved properties after PA cotton is in large-scale commercial production. However, these uses have not been considered as practical potential markets in this report.

TRENDS IN USE OF FABRICS IN COMMERCIAL LAUNDRIES

For over a decade, cotton consumption in the laundry industry has been declining (table 1). For the industry as a whole the quantity of cotton consumed declined from slightly over 134,000 bales of 500 pounds annually in 1947 to less than 75,000 bales annually after 1953--a drop of some 45 percent.

Quantitatively, cotton's losses have been about equally distributed between flatwork ironer materials and press materials. In percentage cotton consumption in flatwork ironer materials dropped approximately 50 percent from 1947 to 1956, while consumption in wash nets dropped nearly 80 percent. In press materials, the drop was about 35 percent, but greater losses are expected unless improvements are made in cotton's functional quality at a cost that will make cotton competitive with the other materials.

---

and experimentation have been done on the development of jute fabrics for lining irrigation canals by the Burlap Council and the Indian Jute Mills Assn., but such fabrics have not been used yet in large volume. The cost advantage of jute does not encourage the development of a competitive product from a much more costly raw material such as cotton. On the other hand, the competitive strength of other materials such as aluminum and plastics stems from long service life.

6/ Improved thermoplastic properties that are associated with highly acetylated cotton might have some useful application in some kinds of clothing in which durable pleating or durable embossing is desirable. Research to date indicates that almost full acetylation would be necessary to achieve these properties.

Table 1.--Consumption of cotton in the laundry industry, 1939, 1947-56 1/

(in 500-lb. gross weight bales)

Year	Total all uses	Flatwork ironer material					Press material				Wash nets
		Total	Cover cloth	Padding	Apron duck	Feed ribbons	Total	Cover cloth	Flannel	Padding	
1939	134,250	57,540	40,010	9,460	7,110	960	63,380	11,940	24,860	26,580	13,330
1947	136,940	64,390	44,440	10,510	8,330	1,110	58,170	11,960	29,570	16,640	14,380
1948	128,940	60,970	41,400	9,780	8,660	1,130	55,280	11,430	32,090	11,760	12,690
1949	109,410	49,820	33,070	7,810	7,910	1,030	49,450	9,420	29,300	10,730	10,140
1950	132,580	49,040	27,880	10,410	10,350	400	71,030	7,570	52,770	10,690	12,510
1951	129,850	48,340	27,300	10,140	10,500	400	72,100	7,680	53,560	10,860	9,420
1952	95,760	45,860	24,820	10,140	10,500	400	44,000	6,960	21,040	16,000	5,900
1953	85,310	39,130	19,760	8,520	10,450	400	40,330	5,430	20,880	14,030	5,850
1954	73,310	31,680	14,370	6,890	10,030	390	37,180	5,270	20,250	11,660	4,450
1955	74,010	31,920	14,470	6,950	10,110	390	37,530	5,320	20,440	11,770	4,560
1956	72,630	32,060	14,540	6,980	10,150	390	37,740	5,350	20,550	11,840	2,830

1/ Data from "Cotton Counts Its Customers" (9).

According to National Cotton Council estimates, cotton's share of the total fabrics used in the following selected laundry uses declined as follows (9):

	Percent of market held by cotton	
	1947	1956
Flatwork ironer cover cloth	90	30
Flatwork ironer padding	90	50
Flatwork ironer apron duck	100	99
Flatwork ironer feed ribbons	98	86
Press cover cloth	80	35
Press flannel	100	99
Press padding	50	30
Wash nets	92	30

These statistics show that cotton's market losses have been concentrated in five categories of materials: (1) Flatwork ironer cover cloth, (2) flatwork ironer padding, (3) press cover cloth, (4) press padding, and (5) wash nets.

Quality requirements for laundry fabrics and materials vary considerably by type of use, whether for flatwork ironers or hot-head presses or for cover cloths or padding, as follows (7):

Item	Desirable quality
Flatwork ironer covers	Resistance to heat Long service life Low cost in relation to performance Smooth finish Freedom from static electricity Dimensional stability Resistance to staining, sticking, or marking off
Flatwork ironer padding	Resistance to heat Resiliency Length of service equal to or greater than life of cover Low cost in relation to performance Permits evaporation of water Dimensional stability
Apron duck (flatwork)	Heat resistance Abrasion resistance Dimensional stability Length of service equal to or greater than life of cover

Item	Desirable quality
Feed ribbons	Dimensional stability Length of service equal to or greater than life of cover
Press cover cloth	Resistance to heat Low absorption of starch Resistance to snagging Smooth finish, no sticking, staining, marking off, or slipping off Long service life Low cost in relation to performance
Press padding	Resistance to heat Resiliency Low absorption of starch and moisture Length of service equal to or greater than life of cover Low cost in relation to performance Transmits moisture
Press flannel	Heat resistance Resiliency Length of life equal to or greater than life of cover Low cost in relation to performance
Wash nets	Light Low absorption Resistance to chemicals Open mesh fabrics Abrasion resistance to insure long service life

Careful analysis of qualities desired for particular uses is necessary for evaluating the cause of shifts in the types of materials used in commercial laundries and as the basis for engineering quality improvements into cotton fabrics to reverse the trend away from cotton to competing materials.

Cotton's principal competitors, by particular uses, are summarized below:

Item	Principal competing materials
Flatwork ironer cover cloth	1. Dacron 2. Asbestos
Flatwork ironer padding	1. Asbestos 2. Nylon 3. Steel wool

Item	Principal competing materials
Press cover cloth	1. Nylon filament 2. Nylon staple
Press flannel	1. Nylon 2. Nylon-cotton blend
Press padding	1. Steel wool 2. Foam rubber
Wash nets	1. Nylon 2. Dacron 3. Nylon-cotton blend

REASONS FOR COTTON'S LOSSES

The decline in the use of cotton fabrics in commercial laundries results from failure of cotton to meet fully the improved qualities of competing materials, failure of cotton manufacturers to match the sales effort and promotion put forth by manufacturers and laundry suppliers on behalf of other materials, and failure in some cases to match competing materials on cost in relation to performance.

Although untreated cotton materials are considerably less expensive initially than competing materials in particular uses, they have, because of quality deficiencies, failed to match some competing materials in terms of cost in use. Therefore, the future use of cotton in commercial laundries depends upon improvements in quality that will lengthen cotton's useful life. This has become a significant factor in competition because of the labor cost and the operating time lost in changing covers and padding. Also, the cost of achieving quality improvements must be low enough to turn the cost-performance ratio in favor of cotton. Even then, considerable sales effort by laundry suppliers will be necessary, and this effort will not be forthcoming unless profit margins on cotton materials are equal to or greater than those for competing materials.

TEST RESULTS OF PA COTTON IN COMMERCIAL LAUNDRIES

The American Institute of Laundering in cooperation with the National Cotton Council and the Southern Regional Research Laboratory has conducted service tests of PA cotton for use as laundry press covers and padding. Results of these tests indicate that (1) the service life of PA cotton is approximately 4 times that of untreated cotton, (2) the service life of PA cotton covers ranges from 75 to 100 percent of that of nylon, (3) PA cotton double-faced flannel had service life approximately equal to that of nylon, and (4) PA cotton fabric proved unsatisfactory for automatic shirt presses because of the adherence of starch from the shirts and the punching of holes in the cover by buttons. Further service tests to evaluate press covers are being made by the American Institute of Laundering.

Other serviceability tests have been conducted by several commercial laundries in cooperation with Southern Regional Research Laboratory technicians over the last several years. The results of these random tests, which were not materially different from those reported by the American Institute of Laundering indicated that the service life of PA cotton press covers ranged from 3 to 6 times the usual life of untreated cotton. The usual ratio reported was 4 to 5 times that of untreated cotton.

Fewer service tests have been made of flatwork ironer cover cloths than for hot-head press materials because of the difficulty of obtaining partially acetylated fabric in 90-inch widths. One test by a commercial laundry on the serviceability of PA cotton flatwork ironer covers indicated that the treated covers had a service life approximately 12 times that of untreated cotton covers. The covers in this particular test were used until the 5/8-inch padding had burned to a powder. After removing the covers in this test, the fabric still retained approximately 50 percent of its initial strength. This indicated that with improved padding material the service life of PA covers would have been even greater. Another service test indicated a useful life of 22 weeks for PA covers as compared with 2 to 4 weeks for untreated cotton covers.

A comprehensive program of product development and evaluation of PA cotton in laundry uses has recently been initiated at SURDD. A task group is making arrangements to obtain PA cotton laundry materials of desired specifications for testing in all laundry uses where PA cotton appears feasible. Cooperative arrangements have been made with selected commercial laundries to conduct the serviceability tests. This series of tests has been designed to cover the full range of possible application of PA cotton in commercial laundries and to provide detailed cost-in-use comparisons between untreated cotton, PA cotton, and competing materials.

Although it would be desirable to have the complete results of the tests now in process or planned as the basis of projecting market potentials, the random serviceability tests that have been conducted in the past and those currently under way by the PA Cotton Task Group of the Southern Regional Research Laboratory do indicate a favorable opportunity for cotton to recapture some of its recent market losses or to prevent further inroads. They also provide a reasonable basis for evaluating the market potential of PA cotton in commercial laundries.

COMPARATIVE COSTS AND PERFORMANCE ESTIMATES

Comparative costs and performance estimates for untreated cotton, PA cotton, and competing materials used in commercial laundries are summarized in table 2. The cost estimates of untreated cotton and competing materials currently in use are based upon list prices as reported by laundry supply trade sources. The price estimates for PA cotton materials were calculated on the basis of estimates contained in a special report prepared by the Engineering and Development Laboratory of SURDD on the cost of producing PA cotton (4) and on information supplied by firms that have produced PA cotton commercially. The cost estimates for PA cotton include a liberal allowance for profit of 50 percent or more of the calculated cost of partial acetylation.

Table 2.--Estimated comparative costs and service life of cotton and other materials used in commercial laundries

Item	Description of materials	Estimated prices to laundries 1/		Estimated service life 2/	Estimated no. units used per year 3/	Estimated labor cost for changing materials 4/	Estimated annual cost 5/	Ratio of cost of other materials to cost of PA cotton 6/
		For quantity comprising a single purchase	Unit cost					
		Dollars	Dollars	Weeks		Dollars	Dollars	
Covers for flatwork ironer rolls:								
Cotton cover	90"x110"	3 per roll	7/ 18.00	2.5	20.8	52.00	426.40	1.56
Dacron cover	90"x110"	23 per roll	7/ 138.00	20	2.6	6.50	365.30	1.34
PA cotton cover 8/	--	8.35 per roll	7/ 50.00	10	5.2	13.00	273.00	--
Padding for flatwork ironer rolls:								
Cotton padding, double	5/8"x74"x110"	9/ 7 per roll	7/ 42.00	12	4.3	10.75	191.35	1.67
Cotton padding, burlap backing	74"x110"	9/ 19 per roll	7/ 114.00	26	2.0	5.00	233.00	2.03
Nylon padding	30 oz., 37"x110"	43 per roll	7/ 258.00	52	1.0	2.50	260.50	2.27
Asbestos (padding & cover) 10/	--	9/ 70 per roll	7/ 420.00	52	1.0	2.50	422.50	--
Steel wool (padding & cover) 10/	--	--	7/ 2,000.00	11/ 104	.5	---	1,000.00	--
PA cotton padding 8/	--	17 per roll	7/ 102.00	48	1.1	2.75	114.95	--
Press cover cloths:								
Cotton covers	51"x19"x9"	11 per doz.	.92 ea.	1.2	43.3	12/ *	39.84	2.24
Nylon filament	51"x19"x9"	32 per doz.	2.67 ea.	3.5	14.9	*	39.78	2.24
Nylon staple	51"x19"x9"	40 per doz.	3.33 ea.	6.0	8.7	*	28.97	1.63
PA cotton 8/	--	20.50 per doz.	1.71 ea.	5	10.4	*	17.78	--
Press padding:								
Cotton (2 pieces)	5/8", 2# yd.,42"	13.50 per doz.	1.13 ea.	3	17.3	*	19.55	1.30
Steel wool (plain)	51"x19"x9"	21.00 ea.	21.00 ea.	52	1.0	*	21.00	1.40
Stainless steel wool	51"x19"x9"	24.00 ea.	24.00 ea.	64	.8	*	19.20	1.28
PA cotton 8/	51"x19"x9"	42.00 per doz.	3.50 ea.	12	4.3	*	15.05	--
Press flannel:								
Double-face cotton	20 oz.,54" wide	13.50 per doz.	13/ 3.38	2.5	20.8	*	70.30	1.93
Nylon	30 oz.,54" wide	52.00 per doz.	14/ 8.67	7.0	7.4	*	64.16	1.76
Nylon (86-14 blend)	30 oz.,54" wide	30.00 per doz.	14/ 5.00	4.0	13.0	*	65.00	1.78
Cotton (terry knit cloth)	20 oz.,54" wide	13.50 per doz.	13/ 3.38	2.5	20.8	*	70.30	1.93
PA cotton (terry knit cloth) 8/	60 oz.,54" wide	84.00 per doz.	15/ 7.00	10.0	5.2	*	36.40	--

See footnotes on page 17.

1/ Average prices to laundries obtained from trade sources.
2/ Service life estimated from information obtained from trade sources, manufacturers' guarantees, and various service tests.
3/ Calculated from estimated service life.
4/ Estimated annual replacement labor cost on basis of information obtained from trade sources.
5/ Annual unit costs plus estimated cost of changing materials.
6/ Obtained by dividing estimated annual cost of other material by the estimated constructed cost for PA cotton material.
7/ For 6-roll flatwork ironer. Material for 6 rolls is the unit.
8/ In making the cost estimates used in this table, the lowest calculated cost figures were not used in any instance, and conservatively high estimates (not taking into consideration chemical recovery in the PA process) were used as a norm. In addition, a liberal markup of 50 percent or more of the cost of partial acetylation was included as probable profit for acetylation and a 25 percent allowance was allowed as profit for laundry supply firms. The estimated acetylation costs used were $1.00 per pound for fabric (includes scouring and dyeing), $1.20 per pound for yarns, and $1.30 per pound for raw stock. Mill sales prices were used for the various cotton materials selected for acetylation. These estimates were based largely on information provided by firms that have had commercial experience in producing PA cotton and consequently are much higher than those presented in a report in process by the Engineering and Development Laboratory of SURDD. Further experience in the commercialization of PA cotton would likely indicate considerable variation from the estimates presented herein; however, for comparative purposes the cost estimates are considered conservative on the basis of existing knowledge, and provide a reasonable basis for making projections of probable comparative costs of PA cotton in relation to untreated cotton and other materials.
9/ Includes binder.
10/ Includes binder, padding and lead cloth. Comparable to the sum of the costs of cover cloth and padding of alternative materials.
11/ Guaranteed life 2 years, actual service considerably higher. Therefore, no attempt was made to compare cost performance rates with other materials.
12/ Asterisk indicates that no cost for changing materials was included because this operation is usually done by the operator during the normal work period and the cost is nominal.
13/ Three flannels normally used. Two obtained per yard.
14/ Two flannels normally used. Two obtained per yard.
15/ One terry knit flannel normally used. Two obtained per yard.

In evaluating the competitive relationships of the various materials used in commercial laundries, it is necessary to estimate two factors other than price: (1) Usual service life, and (2) usual labor cost for replacing materials. These estimates are also included in table 2 and, together with the estimated prices paid for the different materials by laundries, provide the basis for calculating estimated annual costs of the individual materials and for calculating cost-performance ratios.

In each of the five laundry uses included in table 2, the cost-performance relationships indicate a favorable competitive position for PA cotton. Its increased use would be dependent upon large-scale commercial production and availability of PA cotton materials carefully engineered to meet the specific requirements in use. The substitution of PA materials for other materials now being used would also be dependent upon the effectiveness to which they are promoted by the laundry supply houses. The degree to which laundry suppliers promote a new material such as PA cotton will depend largely upon comparative profit margins between PA cotton and competing materials.

PROJECTED PA COTTON MARKET POTENTIAL

Laundry Industry

The five items in the laundry industry for which PA cotton appears feasible are press cover cloths, press flannel, press padding, flatwork ironer cover cloths, and flatwork ironer padding. Although less specific information is available on the suitability and performance of PA cotton as flatwork ironer cover cloths than for other applications, there is reason to believe that suitable fabrics can be produced for this use, which is one of the larger market outlets. However, the problem of engineering a fabric capable of meeting the competition for this use may be much greater than for the other laundry uses considered.

In making estimates of market potentials, the following assumptions were made:

1. That, on the basis of cost-performance projections presented in table 2, PA cotton has sufficient cost and performance advantages to recapture a sizable share of end use markets from competing materials.

2. That if PA cotton had such advantages, it would also displace a sizable share of existing markets currently held by untreated cotton fabrics.

3. That service life of PA cotton in the five uses considered would be approximately 4 times that of untreated cotton.

Market potentials have been projected on the basis of several assumed levels of market penetration (table 3). Although sufficient data from a large number of users on cost of PA cotton in use in relation to cost of competing materials are not available for making exact estimates, the projections do furnish a guide for evaluating the possible impact of substituting PA cotton

Table 3.--Cotton consumption in the laundry industry in 1956 and projected market potentials for PA cotton under assumed conditions

(in 500-lb. cotton bale equivalents)

Item	Press cover cloths	Press flannel	Press padding	Flatwork ironer cover cloths	Flatwork ironer padding	Other	Total
Total cotton consumed in laundry, drycleaning equipment and supplies, 1956 1/	5,350	20,550	11,840	14,540	6,980	13,370	72,630
Percent of market held by cotton 1/	35	99	30	30	50	66	46
Size of market held by other materials 1956 2/	9,937	208	27,627	33,927	6,980	6,888	85,567
Percent of market held by other materials 2/	65	01	70	70	50	34	54
Assumed conditions:							
Market potential for PA cotton if it displaced all other materials 3/	2,484	52	6,907	8,482	1,745	0	19,670
Market potential for PA cotton if it displaced 50 pct. of all other materials 3/	1,242	26	3,454	4,241	873	0	9,836
Market potential for PA cotton if it displaced 50 pct. of the 1956 market held by other cotton 3/	669	2,569	1,480	1,818	873	0	7,409
Market potential for PA cotton if it displaced all other materials plus 50 pct. of the 1956 market for untreated cotton 3/	3,153	2,621	8,386	10,300	2,618	0	27,078
Market potential for PA cotton if it displaced 50 pct. of other materials plus 50 pct. of the 1956 market held by untreated cotton 3/	1,911	2,595	4,934	6,059	1,746	0	17,245

1/ Compiled from "Cotton Counts Its Customers" (9). 2/ Size of market held by other materials expressed in cotton bale equivalents, which represents estimated quantity of cotton necessary to produce sufficient materials to meet commercial laundry requirements now supplied by other materials. Calculations based on data presented in "Cotton Counts Its Customers." 3/ Calculated on basis that service life of PA cotton in press materials and flatwork ironer materials is 4 times that of the untreated cotton equivalent.

for materials now being used in the major laundry items. In estimating potential markets in laundry uses, the projections were made in quantitative terms expressed as "cotton bale equivalents."

It is unrealistic to assume that PA cotton would be substituted across the board for all noncotton materials in the five major laundry items. This projection is made for no other purpose than to determine the "outside" limit of possible potential market gains that could be expected for PA cotton. The size of the market held by noncotton materials can be projected in terms of cotton bale equivalents (calculated from the National Cotton Council estimates of the percentage of the market held by competing materials). Since the indicated service life of PA cotton is approximately 4 times that of untreated cotton, the "outside market potential" for PA cotton of 19,672 cotton bale equivalents can be established by dividing the estimated share of the market held by noncotton materials by 4.

A much more realistic assumption is that PA cotton might be substituted for half of the noncotton materials. At 50 percent penetration, the market potential of PA cotton would be 9,836 cotton bale equivalents. Thus, the potential net gains in cotton consumption would range from 9,836 bales, if cotton were able to displace one-half of all noncotton materials now being used, to 19,672 bales if it displaced all of these materials.

If PA cotton made significant gains versus noncotton materials used in the major laundry items, it is likely that some gains would be made at the expense of untreated cotton. If PA cotton were to displace 50 percent of the 1956 market held by untreated cotton, this could result in an additional market potential for PA cotton of 7,409 cotton bale equivalents. This increased potential for PA cotton would represent a short-term net loss in over-all cotton consumption of 22,227 cotton bale equivalents, because PA cotton would be expected to substitute for untreated cotton at a ratio of 1 to 4. This situation can be expected to prevail in almost any case where the quality improvements needed to prevent market losses to competing materials result in an extension of service life. It is particularly true in industrial uses where the competition turns largely on performance in relation to cost. However, where the market is threatened by competitive materials, the entire market in time conceivably might be lost unless the use qualities of cotton are improved. Therefore, if PA cotton prevented a loss to competing materials, it could reflect a gain in cotton consumption in the long run.

Converted to poundage, the PA cotton potential on the basis of these assumptions would range from 8.6 million pounds at 50 percent penetration of the market for both competing materials and untreated cotton to 13.5 million pounds at 50 percent substitution for untreated cotton fabrics and 100 percent substitution for all noncotton materials.

Home Ironing-Board Covers

On the basis of a preliminary study in 1957, several broad generalizations were reached regarding the market for home ironing-board covers. First, the total market was estimated to range from 35 to 50 million covers annually. Of this market it was estimated that approximately 50 percent was for covers retailing for less than $1.10 each, approximately 30 percent was for covers ranging in price from $1.10 to $1.49 each, and the remaining 20 percent was for covers in excess of $1.50 each. The size of the market in the higher-priced bracket was estimated to range from 7 to 10 million covers in excess of $1.50 each. Therefore, in the market for the most expensive covers, in which category PA cotton covers would fall, the potential volume of all fabrics used would approximate 6 to 9 million yards of cloth.

The analysis of the home ironing-board cover market indicates that the bulk of the fabrics used are sold primarily on the basis of price and eye appeal. Attempts have been made to develop this market for PA cotton, but progress has been slow because treated covers are higher in price, and appearance is not any better than untreated cotton or aluminum-colored silicone-treated materials retailing from $0.60 to $1.10 each. Because of these factors, increased use of PA cotton for home ironing-board covers has been hampered despite the improved heat resistance of PA cotton that gives it greater service life.

On the basis of existing price-cost relationships it is apparent that the upper limit of the market potential for PA cotton if it displaced all higher-priced competing materials would approximate 9,000 bales of cotton on an untreated cotton basis. 7/ If the longer service life of PA cotton resulted in a decline in repeat purchases, the potential market would be reduced in proportion to the increased service life. If the service life of PA cotton is 4 time that of untreated cotton, the actual volume of this market in terms of PA cotton equivalent might not be more than 2,225 bales. If, however, the PA covers were effectively promoted on the basis of increased service, if their general appearance were improved in relation to competing covers, and if prices were lowered as a larger volume of production brought costs down, the potential market for PA cotton covers could be increased. It is not unrealistic to assume, however, that the practical market potential in time would be considerably above the 2,225 PA cotton bale equivalents calculated in this analysis.

7/ Market potential calculated by converting 9.0 million yards of fabric to raw cotton bale equivalent (average weight of fabric assumed to be 8 oz. per square yard).

LITERATURE CITED

(1) Abrams, E.
1950. Microbiological Deterioration of Cellulose During the First 72 Hours of Attack. Textile Res. Jour. 20: 71-86.

(2) Buras, E. M., Jr., Cooper, A. S., Jr., and others.
1954. Practical Partial Acetylation of Cotton. Am. Dyestuff Reporter 43: 203-208.

(3) Buras, E. M., Jr., Hobart, S. R., and others.
1957. A Preliminary Report on Fully Acetylated Cottons. Textile Res. Jour. 27: 214-222.

(4) Decossas, K. M., McMillan, O. J., Jr., and others
1959. Partial Acetylation of Cotton--Cost Analysis Application. Ind. & Engin. Chem. 51(5): 615-618. May.

(5) Goldthwait, C. F., McLaren, J., and Voorhies, S. T., Jr.
1946. Acetylated Cotton Highly Resistant to Rotting. Textile World 96(2): 115-117, 212, 216.

(6) Honold, Edith, Keating, E. J., and Skau, E. L.
1957. Acid and Alkali Resistance of Partially Acetylated Cotton Fabrics. Textile Res. Jour. 27: 400-411.

(7) McCord, F. A., and McCrossan, J. A., Jr.
1949. Cotton in the Laundry Industry. National Cotton Council of America, Utilization Research Division, Memphis, Tenn. Pp. 7-8.

(8) Moncrieff, R. W.
1957. Man-Made Fibers. 3d ed. New York, N. Y. P. 237.

(9) National Cotton Council of America, Utilization Research Division.
1958. Cotton Counts Its Customers; The Quantity of Cotton Consumed in Final Uses in the United States, 1939, 1947-1956. Memphis, Tenn. Pp. 32-33.

(10) Orr, R. S., Weiss, L. C., and others.
1957. Physical Properties of Partially Acetylated Cottons. Textile Res. Jour. 27: 966-975.

(11) Siu, R. G. H.
1950. Mechanism of Microbiological Decomposition of Cellulose. Textile Res. Jour. 20: 281-288.

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON 25, D. C.

Official Business